New Zealand Pollen Studies

1. KEY TO THE POLLEN GRAINS OF FAMILIES AND GENERA IN THE NATIVE FLORA.

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CONTENTS.

INTRODUCTION.

There is now little need to plead the value of pollen research. During the last few years great impetus has been given through the publication of Wodehouse's splendid manual and many monographic papers dealing with morphology and the determination of atmospheric pollen in hayfever studies. New workers have taken up pollen-analytical investigations of bogs in many countries outside Scandinavia, while among others Skottsberg (1936, 1939, 1940) has consistently added pollen characters to systematic descriptions of new species, and Armbruster and Oenike (1929) have traced honey poisons or impurities through surveys of the local and foreign pollen-grains in the German market product. War has arrested the publication of Erdtman's "Pollen Analysis," which has been eagerly awaited for several years.

Nearer home Mercer (1940) has made useful records of seasonal flight of wind-borne pollen in and around the city of Adelaide, and atmospheric slides have been exposed for some time at the Medical School in Dunedin, and at this Museum.

Identification of pollen-grains had proceeded slowly here for various reasons, chief being the lack of any general account of the types to be met with among the native genera in particular. A little has been published overseas by the authors already mentioned. Skottsberg (1936), for instance, has been able to remove our *Pisonia* to *Heimerlia* on the clear-cut evidence of the pollen added to that of other floral characters; Armbruster and Oenike have dealt briefly with a few genera, e.g., *Olearia* and *Sophora,* and Wodehouse (1935, 1936) much more critically with about 32 genera represented in the New Zealand flora, while Auer (1933) in his Tierra del Fuegian bog researches has figured a few types common to the two countries. There are other scattered references, of course, but these seem the most significant.

During the last few years I have been attempting to remedy these deficiencies, and have so far published accounts of the pollen-grains of our beeches and conifers (1938, 1939, 1940). I began this at Professor L. von Post's suggestion (1936), in order to make more detailed analyses of peats than had been possible in our joint preliminary effort, and although I have continued field work on Te Moehau, in the Waikato, and in the South Island and Stewart Island, I feel that the considerable task of describing the pollen types of the flora as a whole has tended to by-pass my real objective—the determination of the narrower range of grains to be expected in quantity in recent deposits.

However, the collection of pollen-slides now available (over 1,200 numbers, with duplicates made by different methods) will be invaluable as reference sets for other workers as well as for myself, especially when the Atlas of figures and descriptions is published. The prior appearance of the key is due to its comparative brevity and its value in identification pending the appearance of the Atlas, which may well be delayed in these times. The main collection will be kept at Auckland Museum, and a second set is being transferred to the Botany Section, Plant Research Bureau, Wellington, in appreciation of assistance given by Dr. H. H. Allan (and his staff) in his supervision of the grant I received between 1937 and 1939. This grant, for which I again express thanks to the Department of Scientific and Industrial Research, covered most expenses and provided an excellent part-time assistant in William F. Harris (now overseas with the 5th Field Ambulance), who made practically all the preparations during that time, exposed atmospheric slides almost daily for 18 months, and followed every stage of the work with care and enthusiasm.

Most of the slides were made from fresh material: in some few cases only dried flowers could be obtained, and for these I am indebted to botanists in a number of herbaria.

SCOPE OF KEY.

The key is planned to enable anyone with elementary knowledge of the subject to track down at least the families of grains investigated. For most applications a generic determination is sufficient, and more is rarely made possible here, in order to save space and possible confusion, unless there are significant breaks within a genus, as between the *Nothofagus fusca* type and the *menziesii* type (Cranwell 1939). In the Atlas a systematic arrangement will allow of short keys to make identifications more precise within many of the genera.

A family may be characterised by a single type of pollen-grain, and where the genera are numerous striking uniformity can usually be recognised. From the systematic viewpoint many families are very weakly represented in New Zealand, and it would naturally take a much wider range of genera to be confident as to the basic form of pollen-grain for a family. In some families more than one type will turn up; comparison has been made with exotic material as far as possible, and this has helped greatly in interpretation, e.g., *Myosotidium* pollen has been contrasted with that of *Cynoglossum (Boraginaceae)*, *Carpodetus* with that of the Lord Howe *Colmeiroa* (in the same section of the *Saxifragaceae)*, and so on.

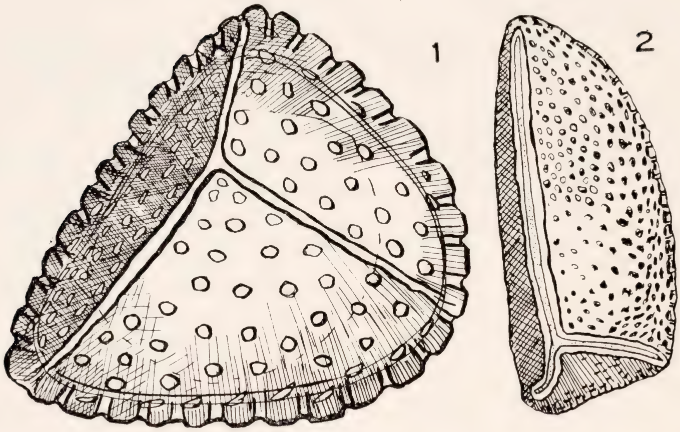
Altogether 105 families are dealt with, 339 genera being under survey, and Hutchinson (1934) has been followed in separating the *Agavaceae, Smilacaceae* and *Philesiaceae* from the *Liliaceae* and in removing *Hypoxis* from the *Amaryllidaceae.* Practically all the genera have been keyed. The Kermadecs *Ageratum* and *Canavalia* (both three-furrow types), *Ewartia, Scleranthus, Logania* (male flowers not available) and the elusive *Phrygilanthus* are the exceptions among the dicotyledons. On the other hand, poor material of a few genera was available, so that *Korthalsella, Spergularia* and *Tetrachondra* are placed with some hesitation. In the monocotyledons three were neglected of necessity, and a number from choice (a) in the grasses, whose grains are so very uniform, (b) in the orchids, where very few types occur; in both these families detailed work seemed more suited for special study in leisurely times. *Zostera* pollen is well known, but the species rarely flower in this country; male flowers were collected by Miss L. B. Moore and myself at Doubtful Sound in 1940, but were lost on the same trip. *Lemna* pollen was not found; according to Hegelmaier's figure and note (1868) it belongs, as would be anticipated, in Section I:A:; its exact position there will depend on whether the intine is thin or thick and the exine continuous. Of *Hydatella* (Juncella) male flowers have never been found.

Whatever the shortcomings of the key, it should relieve much tedious work in eliminating the host of "possibles" that bewilder the investigator of our peats, etc., in the beginning; and I trust it will give an idea of how closely the pollen-grains reflect phylogeny, and of how much more attention they should receive in systematics. Some evidence in the ever-fresh monocotyledon-dicotyledon controversy is given here, but not reviewed. That must wait, fascinating as it is.

Are Pollen Grains Distinctive?—It is worth stressing here that pollen-grains should not readily be confused with other bodies in mixed preparations. The following sketches (text figs. 1 and 2) and key show how they differ from most pteridophyte spores:—

Grains with triradiate crests—**Spores** of ferns and fern allies.

Grains without triradiate crests—**Pollen Grains** of flowering plants.



Text figs. 1 & 2: Spores of Flowerless Plants, showing the triradiate crest.

1. Lycopodium varium spore (44μ in diameter; Factor 2; see p. 285); crest almost symmetrical.
2. Tmesipteris tannensis spore (72μ in diameter; Factor 1; see p. 285); crest strikingly asymmetrical. The short arms of the crest may be more reduced in Tmesipteris and Psilotum.

Reference to a case of superficial similarity was made as follows (Cranwell 1940): "In peats, etc., the most reduced forms of rimu pollen might be confused with *Lycopodium* spores. The author has found the two together in surface peats from Te Moehau. The spores were larger, however, and were characterised by coarser sculpture, a clear golden colour, and their more or less strongly developed triradiate crests along whose lines rupturing occurs." Wodehouse (1935) points out that *Abies* and some genera of the *Magnoliaceae* possess signs of a crest whose arms he considers to be "homologous with the radii of the triradiate crest of fern spores."

Teleutospores of fungi are, of course, easily recognised; other types of spores can be eliminated by reference to the very small Acolpate section in the master key.

POLLEN TERMINOLOGY.

Few definitions are really necessary, as it is taken for granted that readers will have access to Engler's account of the angiosperms (1926) and especially to Wodehouse's "Pollen Grains" (1935).

ACOLPATE: Lacking furrows and pores.

ASPIDATE: With a shield-shaped thickening around a germ-pore, associated with the exine or more often below it; e.g., Nothofagus (fusca type), Haloragis, Coriaria (Pl. 55, fig. 17) and causing the "pouting" characteristic of these pores: associated with anemophily.

CELL CONTENTS, likewise, are not stressed, unless they have striking hyaline bodies assisting in the rupturing of the walls, e.g., in the Juncaceae, and below the pore-membrane in some of the Papilionaceae.

COLPATE: Possessing furrows and/or pores.

CROSS (or transverse) **FURROW:** An elongate gap, usually in the inner wall of the exine, crossing furrow at 90° on equator; e.g., Araliaceae; sometimes confluent, e.g., Exocarpus.

DORSAL (proximal): Referring to the side of the grain originally facing inward in tetrad formation.

EXINE: The cuticularised outer coat of the grain, very resistant, and therefore very important in fossil studies. Its **texture** may be rough, or smooth; its **pattern** (including sculpture and structure sensu Erdtman 1936) may be lacking, but is generally flecked-granular; warty-papillate; truly pitted (a cycad character, according to Wodehouse (1935), seen in Agathis also); reticulate-pitted or reticulate (the lacunae or pits rather small), lophate (pits very large, e.g., Taraxacum); spiny or spinulose or echinolophate). See Plates 53-55. **Thickness** may be very useful in identification. The following grading has been used throughout, and will be found useful, but it must be remembered that the layers of the exine swell differently in preparation. Erdtman's method (1936) causes considerable swelling, and is preferred for fossil grains.

Measurements of Exine.

Very thin	1μ or less
Thin	about 1.5μ
Fairly thick	about 2μ
Thick	2-3μ
Very thick	over 3μ

Exine may be lacking in some water-plants, e.g., Zostera.

FURROW CONFIGURATION: For descriptions see Wodehouse (1935, Chapter VII.).

FURROW RIM; PORE RIM: Lips of the furrow and pore respectively.

GERMINAL FURROW: A groove or opening in the exine which provides for (a) volume-change, permitting the intake rapid of moisture, and (b) the passage of the pollen-tube, either through a pore or through a break in a poreless (e.g. Ranunculus) or weakly pored furrow membrane (e.g., Cruciferae).

GERM PORE: The papilla-like place from which the pollen-tube emerges; enclosed by the furrow membrane, as in Celmisia (Pl. 54, fig. 13) or penetrating the exine through loss of the furrow, as in Paratrophis (Pl. 55, fig. 16): sometimes with a **vestibule,** e.g., Fuchsia, Coprosma, Corynocarpus (Pl. 55, fig. 15) between the aperture and th einner wall of the exine flooring the pore or modified furrow.

INTERCOLPAR: Referring to surface areas lying between the furrows.

INTINE: The essential coat, normally thin, perhaps thickened below furrow or pore, often increasing greatly in thickness when the exine and its organs are reduced. As the intine is destroyed by many methods of preparation, and as it is not preserved in peats (though often reported from fossil material), it is not given much emphasis in this key, unless its fresh condition is especially striking, as in the following examples:—

(a) Furrow weakly defined: intine locally thickened—Laurelia novae-zelandiae and Collospermum hastatum (syn. Astelia solandri).

(b) Furrow eliminated: intine enormously thickened "over circuit of grain" (Smith and Wodehouse, 1938)—Agathis and members of the Lauraceae (Beilschmiedia, Pl. 53, fig. 1).

VENTRAL (distal): Referring to the side originally facing outward in the tetrad, very clearly recognisable in Podocarpus (Pl. 53, fig. 6).

PERCENTAGES FOR FURROW AND PORE DISTRIBUTION IN THE GENERA.

About 95% of the grains are simple; in something less than 5% is retention in tetrads obligate. *Drimys* and *Drosera* are characterised by such tetrads, while in certain species of *Epilobium* and in many of the orchids, grains may occur either closely or loosely united, or they may even be quite free. Because of this diversity the percentages are based on the nature of the single unit, even where tetrads may occur.

ACOLPATE		10.5%
COLPATE		89.5%
One furrow	11.5%	
One pore	10%	
Two pores	1.5%	
More than two pores	11.5%	
More than one furrow (typically with 3 furrows and pores)	55%	

Plates 53-55. Figs. 1-25. Illustrating exine patterns, furrow configurations, behaviour of furrows and pores, etc. All grains are greatly enlarged, having been drawn 1,000 (Factor 1), 2,000 (F.2), or 4,000 (F.4) times natural size, and reduced one-third in reproduction for this paper.

Plate 53. Figs. 1-6.

1. Taraire (Beilschmiedia taraire : Lauraceae); **Acolpate:** exine spiny; intine very thick; size 32μ (Factor 2).
2. Tutu (Coriaria arborea : Coriariaceae). Reduced **Tricolpate,** showing internal thickening around pores; size 22μ (F.2).
3. Candlenut (Aleurites moluccana : Euphorbiaceae). **Acolpate:** exine spiny; size 38μ (F.1).
4. Horopito (Drimys axillaris : Magnoliaceae). **Tetrahedral Tetrad,** the components **Monocolpate.** Exine open-reticulate; size of components 23μ (F.2).
5. Hutu (Ascarina lucida : Chloranthaceae). **Monocolpate:** furrow unexpanded (type rare in dicotyledons). Exine pitted; size 23μ (F.2).
6. Miro (Podocarpus ferrugineus : Podocarpaceae). **Monocolpate,** bearing bladders or air-sacs. Size of grain 60μ (F.1). (a) furrow open; (b) furrow closed and bladders drawn together.

Plate 54. Figs. 7-14. Tricolpate Types, mainly polar views.

7. Mitrasacme novaezelandiae : Loganiaceae. Exine pebbled; furrows unexpanded; size 19μ (F.2).

8. Piripiri (Acaena sanguisorbae : Rosaceae). Grain angled, with smaller papilla-like pores between angles; furrows obsolescent. Exine faintly reticulate or granular; size 24μ (F.2).

9. Whau (Entelea aborescens : Tiliaceae). Equatorial view with one furrow showing; note 2 pores. Exine reticulate-pitted; size 26μ (F.2).

10. Kowhai (Sophora microphylla : Papilionaceae); grain over-expanded, rupturing the weak furrows. Exine patternless; size 24μ (F.2).

11. Iceplant (Mesembryanthemum australe : Aizoaceae). Exine granular-papillate; size 23μ (F.2).

12. Taraxacum magellanicum (Compositae). Exine echinolophate; i.e., armed on ridges of lacunae. Note that furrow consists of 3 linked lacunae. Size 16μ (F.4).

13. Celmisia coriacea (Compositae). Exine spiny; size 20μ (F.2).

14. Pachystegia insignis (Compositae). Surface granular, with massive spines; size 20μ (F.2).

Plate 55. Figs. 15-25.

15. Karaka (Corynocarpus laevigatus : Corynocarpaceae). **Dicolpate,** patternless; size 22μ (F.2).

16. Milktree (Paratrophis opaca : Moraceae). **Dicolpate,** patternless; size 17μ (F.2).

17. Tutu (Coriaria arborea : Coriariaceae); see 2. Furrows almost eliminated; exine flecked; size 20μ (F.2).

18. Rata (Metrosideros robusta : Myrtaceae). Furrows linked; size 16μ (F.2).

19. Toru (Persoonia toru : Proteaceae). Three-pored; furrows lost; exine papillate-granular; size 42μ (F.1).

20. Parapara (Heimerlia brunoniana : Nyctaginaceae). Fifteen-furrowed (furrows coinciding with pores); exine flecked. **Reduced type.** Size 48μ (F.1).

21. Alternanthera sessilis (Amaranthaceae). Twelve-pored; lophate; size 15μ (F.2).

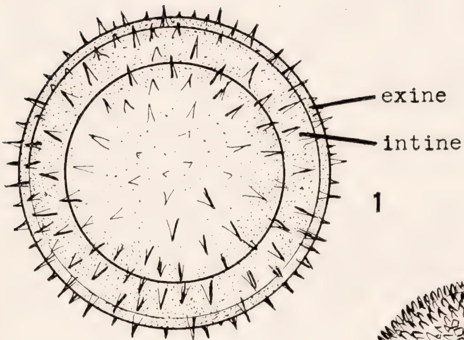
22. Kohekohe (Dysoxylum spectabile : Meliaceae). Furrows 4, vestigial; exine flecked; size 36μ (F.1).

23. Glasswort (Salicornia australis : Chenopodiaceae). Many-pored; exine flecked; size 23μ (F.2).

24. Hibiscus trionum (Malvaceae). Many-pored; surface pitted, bearing long spines; size 130μ (F.1).

25. Kaiku (Parsonsia heterophylla : Apocynaceae). Furrows lost; pores with ornamented collars; exine patternless; size 26μ (F.2).

PLATE 53.



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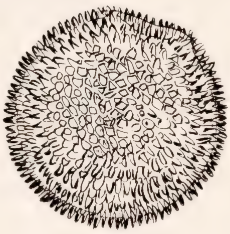

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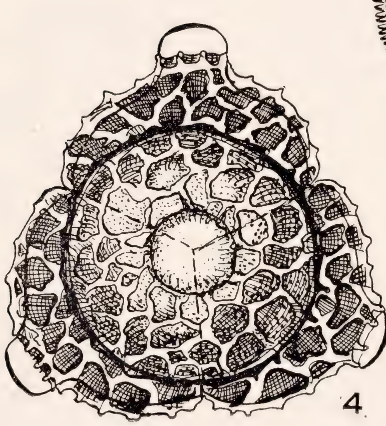

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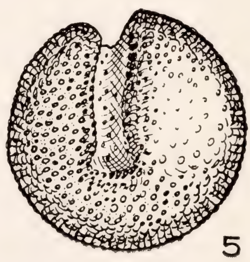

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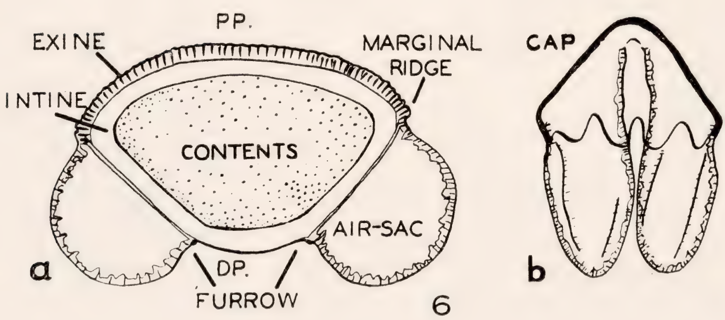

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PLATE 54.

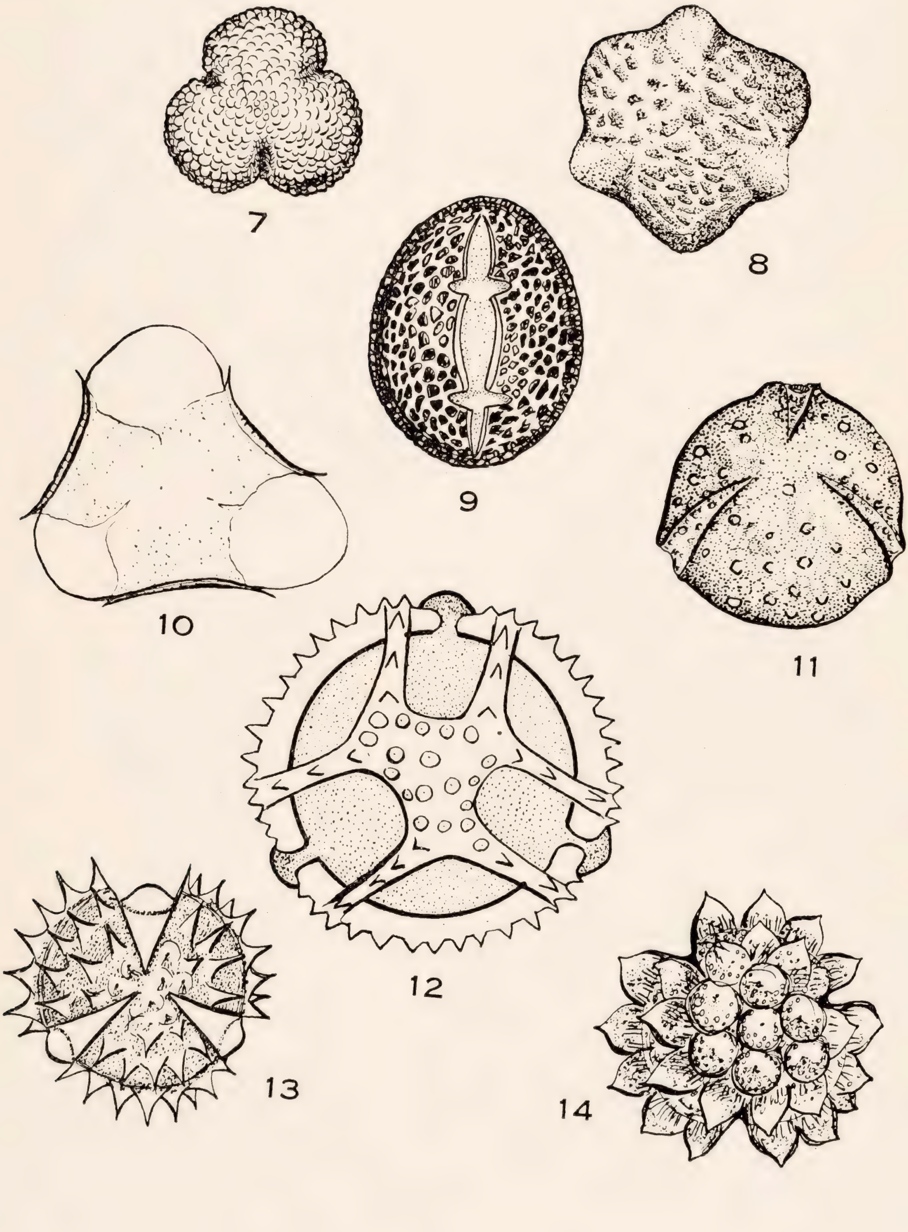
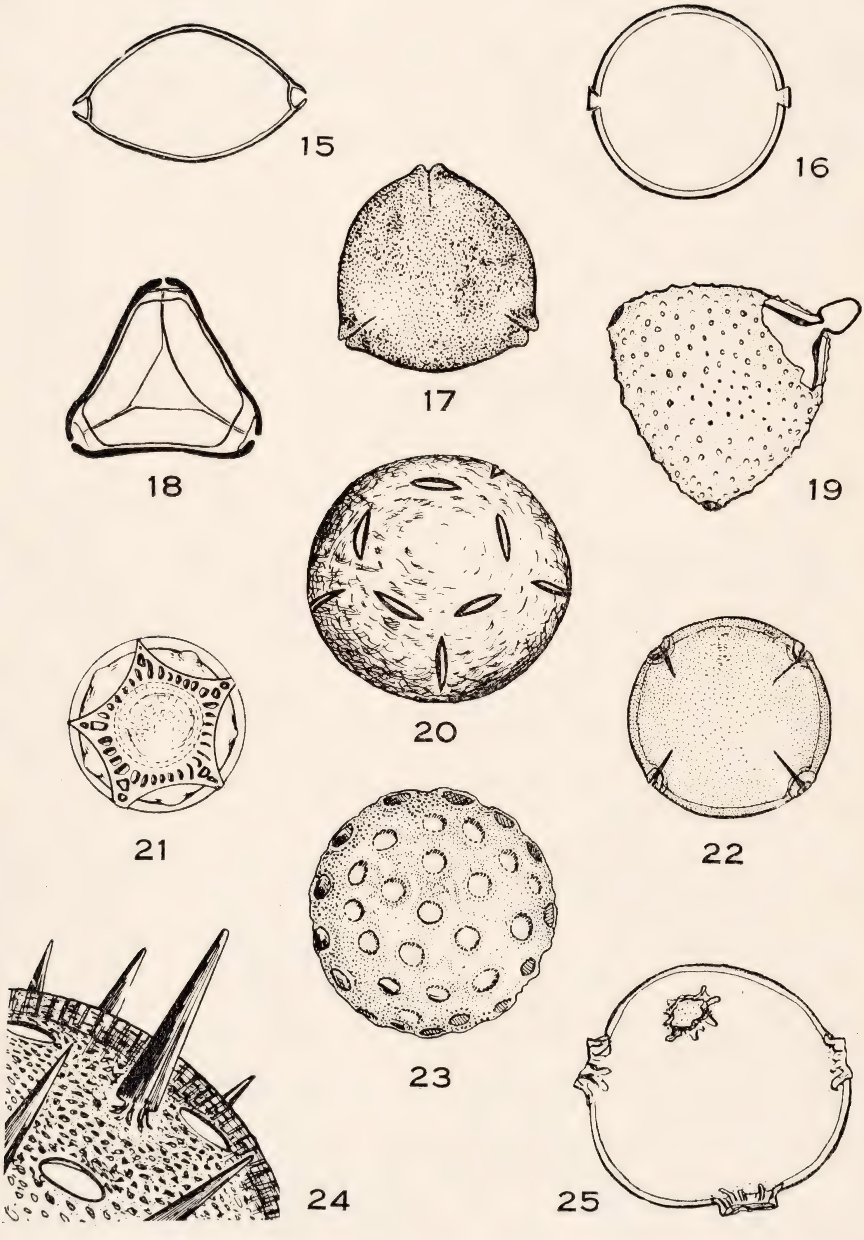


PLATE 55.



PAGE INDEX TO MAIN DIVISIONS OF THE KEY.

MASTER KEY.

(*Signifies treated under more than one heading, owing to the diversity in exine pattern, or to behaviour of the furrow.)

Measurements are in microns: unless otherwise stated they always refer to size of the grains, which range from 6μ (Myosotidium) to 130μ (Hibiscus).

$\mu = 0.001$ mm.

I. GRAINS SIMPLE.

(A) **GRAINS ACOLPATE,** i.e., **without furrows and pores, or recognisable vestige of them.** Exine almost invariably very thin and collapsible; intine often very thick, swelling greatly when moist. **Reduced forms.**

1. Exine lacking over all or part of grain; intine not thick.
   - (a) Grain elongate.
     Grain threadlike, up to 2,500μ long; exine lost or suggested by odd granules .... NAIADACEAE
     Zostera†

     Grain arcuate, 50 to 70μ long; exine reticulate except over ends and on convex side .... NAIADACEAE
     Ruppia
   - (b) Grain spheroidal, 25 to 35μ, reduced reticulate ... NAIADACEAE
     Size 30μ or more .... **Lepilaena**
     Size less than 30μ .... **Zannichellia**
   - (c) Grain spherical, spinulose .... LEMNACEAE
     Lemna‡

2. Exine continuous; intine typically very thick.
   - (a) Exine spinulose.
     Spines crowded, blunt; 36μ .... EUPHORBIACEAE
     Aleurites

     Spines scattered, sharp .... LAURACEAE
     - Spines conspicuous, up to 2μ long.
       Size 32 to 42μ; intine 4 to 6μ .... **Beilschmiedia**
       Size 25 to 32μ; intine thinner .... **Litsaea**
     - Spines weak, rather warty; 24μ .... **Cassytha**

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†Pollen not examined by author.
‡Tentative position.

(b) Exine not spinulose.

Grains spherical, or almost so.

Exine pitted or flecked, intine swelling enormously. CONIFERAE
- Size 40 to 50μ; exine truly pitted .... **Agathis**
- Size 24μ; exine flecked .... **Libocedrus**

Exine reticulate-pitted, collapsing .... CYPERACEAE§

Exine reticulate, firmer.
- Size 9 to 14μ; exine weak .... PIPERACEAE **Peperomia**
- Size 26μ; exine weak .... NAIADACEAE **Potamogeton**

Grains not spherical.

Grain ellipsoidal; reticulate-pitted; 36 to 46μ MONIMIACEAE **Laurelia****

Grain "oblong," strongly reticulate, 28μ .... ORCHIDACEAE **Orthoceras** type

Grain "humped" on one side, flat on the other; 17 to 12μ; patternless .... BAGNISIACEAE **Bagnisia**

(B) **GRAINS COLPATE,** i.e., **with furrows and/or pores.**

1. **GRAINS MONOCOLPATE,** i.e., with a single furrow or pore, sometimes vestigal.

(a) **Bladders present.** Grain with a dorsal "cap," and a distensible membrane flooring furrow on ventral side. Bladders 2, rarely 3, sometimes fused .. PODOCARPACEAE (Pl. 53, figs. 6a, 6b).

(1) Bladders 2; furrow elongate.

Bladder thickenings radial, coarse; cap not strongly pitted; grains 33 to 50μ; and 52 to 74μ overall **Dacrydium kirkii**, **D. biforme**, **D. bidwillii**

Bladder thickenings reticulate, delicate; cap pitted; furrow more active; grains mainly over 45μ; and 45 to 86μ overall .... **Podocarpus** (excl. **P. dacrydioides**)

(2) Bladders 3, fused, enclosing a triangular or almost circular furrow; cap thick, usually pitted.

Membrane triangular; bladders 3, large, delicate, with reticulate thickenings; cap very thick, grains 42 to 52μ; size overall about 75μ ..... **Podocarpus dacrydioides**

Membrane not angular.
- Bladders fused or almost so .... **P. dacrydioides** (about 5%)
- Bladders rudimentary, thickenings radial; size 38 to 48μ .... **Dacrydium cupressinum**, **D. kirkii** group (atypical)

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§For Cyperaceae sometimes involved, refer to section I. (B) (b) (2), giving the typical (i.e., less reduced) forms.

**Not typical.

(3) Bladders rudimentary, forming frills projecting little beyond the body of the grain; thickening radial, coarse; furrow shallow.

Size about 45μ; cap coarsely granular to reticulate; exine very thick .... **Dacrydium cupressinum**

Size 21 to 30μ; cap flecked; exine thin; bladders clearer .... **Phyllocladus**

(b) **Bladders absent;** furrow either **strongly functional,** and then deeply invaginated when unexpanded, becoming very conspicuous when expanded; or **much reduced,** the intine generally being enormously thickened below furrow or now more pore-like area .... most MONOCOTYLEDONS few DICOTYLEDONS

(1) **Furrow very well defined.**

a. Grain angular, flattened; furrow sharply 3-armed when unexpanded, crestlike.

Exine strongly reticulate, mesh weaker over membrane; 30-40μ .... AGAVACEAE **Phormium**

Exine finely pitted; 27μ .... LILIACEAE **Herpolirion**

Exine patternless; 32μ .... LILIACEAE **Dianella**

b. Grain elongate; furrow very long.

i. Furrow wide, rims typically thickened; channelled when unexpanded, membrane bulging when expanded.

Exine rather thick.

Size 50μ, membrane patternless.

Exine flecked .... PALMAE **Rhopalostylis**

Exine granular-pitted .... LILIACEAE **Bulbinella**

Size 30μ or less.

Size 30μ; reticulate to pitted; smoother on membrane .... AGAVACEAE **Cordyline indivisa**

Size 24μ; pitted all over .... CHLORANTHACEAE **Ascarina**

Size 10 to 16μ; exine pitted, warty on membrane .... PIPERACEAE **Macropiper**

Exine thin, pitted all over.

Size 28 by 16μ, pits faint .... LILIACEAE **Iphigenia**

Size 33μ; pits stronger .... HYPOXIDACEAE **Hypoxis**

Exine exceedingly thin, patternless; 30 by 22μ IRIDACEAE **Libertia**

ii. Furrow narrow, sometimes riftlike; rims unthickened.

Exine reticulate or pitted; furrow usually clear.

Furrow almost encircling grain; mesh graded;
40μ .... MONIMIACEAE
Laurelia*

Furrow much shorter.

Size 28μ; grain flattened; mesh bold opposite furrow .... AGAVACEAE
Cordyline banksii, australis

Size 44 by 30μ; mesh reduced against furrow .... LILIACEAE
Arthropodium

Exine granular; furrow weaker.

Size 23μ papillate .... LILIACEAE
Astelia trinervia*
A. cunninghamii*

Size 33μ; exine flecked .... SMILACACEAE*
Ripogonum

Size 40μ; exine flecked .... PHILESIACEAE*
Luzuriaga

(2) **Furrow vestigial,** reduced to a rounded porelike area, or indicated only by a rift in the exine. Exine very thin, pattern reduced; intine typically very thick, swelling to rupture weak area.

Grains spheroidal; more ellipsoidal when unexpanded.

Furrow rift crescentic; exine reticulate; 24μ
NAIADACEAE
Triglochin

Furrow barely indicated; broad or striplike.

Exine papillate .... LILIACEAE

Size 23μ; papillae sharp .... **Astelia trinervia***
A. cunninghamii*

Size 35μ; granules of 2 sizes .... **A. nervosa**

Size 40μ; exine with surface and embedded granules .... **Collospermum hastatum**

Exine flecked.

Size 33μ .... SMILACACEAE*
Ripogonum

Size 40μ .... PHILESIACEAE*
Luzuriaga

Size 50μ; finely pitted .... RESTIONACEAE
Leptocarpus

Exine pitted-reticulate; 30μ .... CYPERACEAE
Fimbristylis

Exine pitted with shining granules; 24 to 34μ
CENTROLEPIDACEAE
Hydatella (Juncella)?†

Size 34μ; exine granular .... **Gaimardia**

Size 24μ; exine fragmented .... **Centrolepis**

Grains typically pouch-shaped, the "pores" constricted by coarsely granular collars; exine characterised by brilliant embedded and additional surface granules .... RESTIONACEAE

Exine very thick; 40μ .... **Calorophus (Hypolaena)**

Exine thin.

Pattern bold, continuous; 32 to 40μ .... **Lepyrodia**

Pattern weak all over .... **Lepyrodia**

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†Male flowers of the native species so far unknown.

Grains ovoid, wedge or gourd-shaped. Furrow-pore at broad end; mesh usually obscure ... CYPERACEAE

Pore smooth; exine flecked-pitted.
Size 30μ .... **Mariscus***
Size 40μ .... **Schoenus**
Size 40μ; pitted .... **Carex** spp.
Size 45 to 55μ .... **Eleocharis***
Pore rough; granules few; 38μ .... **Uncinia**

Pore granules numerous.
Exine mainly pitted; grains angular.
Size 30μ .... **Scirpus nodosus**
Size 40μ; intine very thick at 3 angles ... **Oreobolus***
Size 45 by 27μ .... **Desmoschoenus**
Size 45 to 55μ .... **Eleocharis***
Exine mainly flecked; 46 to 56μ.
Exine meshed; grain curved at narrow end .... **Carpha**
Exine pitted; grain ovoid .... **Eleocharis***

Grains almost spherical; "furrow" obscure; exine flecked.
Size less than 30μ .... **Cladium sinclairii**
Size 30 to 40μ .... **Oreobolus***
Mariscus*
Lepidosperma

(3) **Furrow completely lost: pore small, sharply defined.** Grains ovoid or spherical; exine very thin.

Pore not striking; intine thick under pore.
Exine pitted.
Pits bold; 22μ .... SPARGANIACEAE
Sparganium
Pits weak; 30μ .... TYPHACEAE
Typha
Exine patternless; pore lateral if grain ovoid; 16 to 24μ .... PANDANACEAE
Freycinetia

Pore striking, brilliantly rimmed, with central operculum or cover; exine flecked; intine fairly thick; 20 to 70μ .... GRAMINEAE
Size over 40μ .... e.g. **Danthonia**
Arundo
Size well under 40μ .... e.g. **Festuca**
Poa

2. **GRAINS NOT MONOCOLPATE: typically tricolpate,** very rarely **dicolpate,** sometimes **hexacolpate** (or tetracolpate by reduction), or **polycolpate.**

(a) **FURROWS STRONGLY DEFINED;** typically 3, meridional (tricolpate), each with a nequatorial pore: 6 or 4 furrows not uncommon; never 2 in normal grains. **Furrowed grains.**

(1) **EXINE SPINY.**

Furrows 5-8, meridional; spines short, blunt; 55μ
CUCURBITACEAE*
Sicyos
Furrows and pores 3 or occasionally 6 or 4.

Surface patternless or granular; grains usually oblately flattened; size 14 to 34μ ... COMPOSITAE

Surface flecked at most; furrows typically short; pores compensatingly large.

Spines small.

Size typically less than 20μ; pores very large .... (**Inuleae**)

Size 14 to 20μ .... **Gnaphalium: Raoulia**
Leucogenes: Cassinia
Helichrysum

Size 30μ; spines widely spaced ...... **Craspedia**

Size typically 20 to 25μ .... (**Senecioneae**)

Furrows long and well-defined; spines about 2.5μ .... **Brachyglottis**

Furrows much weaker.

Spines less than 3.5μ, crowded ...... **Traversia**
Erechtites

Spines 3.5μ; widely spaced (6μ) ...... **Senecio**

Spines large; up to 6μ long; 20μ ...... (**Heliantheae**)

Spines very long, curved .... **Bidens**

Spines much shorter, bases broader
Siegesbeckia

Surface granular; furrows stronger; pores often large; spines typically rather short, broad-based, conical, hexagonally grouped.

Surface rather coarsely granular; spines sharply pointed; 17 to 34μ ...... (**Anthemideae**)

Granulation heavy; furrows strong; over 20μ .... **Cotula**

Granulation and furrows weaker; less than 20μ.

Pores very large; spines 3.5μ; 18μ .. **Abrotanella**

Pores and spines smaller; 16μ .... **Centipeda**

Surface weakly granular; furrows tapering strongly; 20 to 33μ .... (**Astereae**)

Spines massive, over 4μ, striate except for tips; 33μ .... **Pachystegia**

Spines not massive, very short, or up to 4.5μ.

Furrows tending to rupture.

Spines 3 to 4.5μ; 20 to 30μ .... **Celmisia**

Spines short; 20μ .... **Brachycome**

Spines very short; 20 to 27μ .... **Olearia**

Furrows not rupturing; spines short.

Furrows short; size 25μ .... **Lagenophora**

Furrows long; spines crowded; 20 to 24μ .... **Pleurophyllum**
Vittadinia

Surface echinolophate, lacunae polygonal. Grains tricolpate, or tetracolpate (the furrows then modified).

Lacunae few (15 or 20), functionally differentiated, 3 or 4 alternate on equator occupied by conspicuous pores; polar plates present; furrows modified; spines long, sharp .... COMPOSITAE (**Cichorieae**)

Furrows typically 3; (lacunae 15).
Size 16 to 26μ; ridges high, spines long; plates bold .... **Taraxacum**
Size 26 to 36μ, plates mainly 3- or 6-armed.
Plates striplike .... **Crepis, Picris**
Plates broad; spines longer .... **Microseris**
Furrows typically 4; (lacunae 20), 26-33μ ... **Sonchus**

Lacunae many, functionally undifferentiated; furrows long, tapering, membrane smooth, pore or whole membrane bulging.
Mesh uniform; 26μ .... STACKHOUSIACEAE
Stackhousia*
Mesh larger in intercolpar areas; 20 to 45μ
GENTIANACEAE
Gentiana*

(2) **EXINE RETICULATE** (tending to grade into (4) see p. 297); furrows tapering.

Furrows interrupted by 2 pores; 23 to 30μ ..MYOPORACEAE
Myoporum*

Furrows with a single equatorial pore.

Pattern unmodified, or almost so, over membrane; furrows ill-defined.
Exine thick, mesh bold; pores large.
Grains over 45μ, uniform .... GERANIACEAE
Size 50μ; mesh rigid .... **Pelargonium**
Size 45 to 80μ; exine thicker, mesh more open .... **Geranium**
Grains less than 45μ; mesh smaller.
Furrows 3, 6, outlined, and membrane transversed by coarse granules; 30 to 40μ .... OXALIDACEAE
Oxalis
Furrows 4, 3, not defined by granules; 28μ
STYLIDIACEAE
Donatia*
Exine thin; pores lacking or obscure.
Mesh very bold, strongest in intercolpar area
CRUCIFERAE
Mesh continuous; 20μ .... **Notothlaspi**
Mesh irregular against membrane; 25μ..**Cardamine**

Mesh reduced, rather granular; 18μ .... OLEACEAE
Olea*
Pattern terminating (and reduced) at furrow margin; furrows diamond-shaped; pores circular, conspicuous.
Exine thick.
Ridges and mesh rough; pores not large.
Size 25 to 45μ; ridges subechinate
GENTIANACEAE
Gentiana*
Size 26μ; ridges pebbled ... STACKHOUSIACEAE
Stackhousia*
Ridges of mesh smooth; pores large.
Cross-furrow present; exine very thick; 30μ .... ARALIACEAE
Meryta
Cross-furrow lacking; exine thinner; 27μ
VERBENACEAE
Avicennia
Exine thin; membranes tending to rupture; pores weakly defined ... SCROPHULARIACEAE

Size 25μ; furrows expanding to give angular outline .... **Ourisia**
Size 36μ .... **Siphonidium**
Size 45μ; furrows narrower and less vigorous; mesh fainter .... **Euphrasia**

(3) **EXINE RETICULATE-STRIATE** ("finger-print" pattern).
Furrows diamond-shaped, not meeting; grains spheroidal; size 27μ .... CARYOPHYLLACEAE **Hectorella**
Furrows very narrow, untapering, commonly 4, joining to form angular "islands" at the flattened poles; 28μ .... GENTIANACEAE **Liparophyllum***

(4) **EXINE PITTED** (reduced reticulate), the lacunae rounded or angular, mainly less than 2μ across (see also reticulate).
Exine boldly pitted, typically rather thick.

Furrows coinciding with elliptic pores, 3 or 6; 35μ .... HALORAGIDACEAE **Gunnera***
Furrows normally developed.
Furrows long and wide, tapering sharply.
Pore rims thickened.
Exine thick; pores large, elongate, without vestibules; 28 to 44μ ..... GOODENIACEAE
Size 28μ .... **Scaevola**
Size 44μ .... **Selliera**
Exine thinner; pores small, circular, with large vestibules; 25μ .... CORNACEAE **Griselinia**
Pore rims unthickened, pores small or obscure.
Exine thick; pores papillate; 20 to 45μ EUPHORBIACEAE
Size 20μ; pits angular .... **Poranthera**
Size 33μ; pits rounded .... **Euphorbia**
Size 38μ; pits irregular .... **Homalanthus**

Exine thin.
Surface smooth; furrows 3, 6 or 4.
Size 23 to 30μ; 2 pores often clear in each furrow .... MYOPORACEAE **Myoporum***
Size 33μ; pits irregular .... TILIACEAE **Entelea**
Surface corrugated; pits small, round; exine thinner; 28 to 35μ ... VERBENACEAE **Vitex**
Furrows long and narrow.
Pores sharply defined, underlain by cross-furrows.
Exine thick; pores typically transverse.
Pitting bold; furrows very narrow; 30μ SAPINDACEAE **Dodonaea**
Pitting less bold; furrows wider.
Size 32μ; pores long .... CONVOLVULACEAE **Dichondra***
Size 26μ; pores shorter; cross-furrows almost encircling grain .... ARALIACEAE **Pseudopanax**

(4) contd.

Exine thin; furrows almost taperless.

Size 28 to 38μ .... ARALIACEAE
Nothopanax arboreum type

Size 24μ; pores sometimes circular
POLYGONACEAE
Muehlenbeckia*

Pores not sharply defined; furrows 3, 6 or 4.

Membrane patternless; furrows 3; 23μ
CRUCIFERAE
Lepidium

Membrane patterned except for narrow confining strips, probably representing furrows; exine thin.

Furrow-strips 6, in 3 pairs; 35μ
PASSIFLORACEAE
Tetrapathaea*†

Furrow-strips 3, or 4 (narrow only when unexpanded); mechanism very vigorous; 42μ .... VERBENACEAE
Teucridium*†

Exine not boldly pitted; texture smooth; furrows 3, otherwise 6, 4, or rarely 5.

Pores lacking; furrows narrow; 32μ .RANUNCULACEAE
Anemone

Pores present, but sometimes obscure.

Pores large, with very elastic membranes; furrows spindle-shaped, often tearing
PAPILIONACEAE

Pores oblong.

Pores meridional; 28μ .... **Clianthus**

Pores transverse.

Size 26μ .... **Corallospartium**

Size 18μ .... **Swainsona**

Pores not oblong.

Pores elliptical; 16 to 30μ .... **Carmichaelia**

Pores circular; 20 to 23μ .... **Chordospartium**
Notospartium

Pores small, often forming bulges in furrow membrane; furrows long, mainly narrow, tapering.

Pores sharply defined.

Furrows rather wide.

Size 14μ .... CUNONIACEAE
Weinmannia

Size 22μ .... RUTACEAE
Melicope

Furrows narrow.

Pores slitlike, with cross-furrows.

Exine thick; 38μ .... CONVOLVULACEAE
Dichondra*

Exine thin; 22μ .... ARALIACEAE
Nothopanax simplex type

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†Quite aberrant types, impossible to understand without reference to related forms in other floras. *Tetrapathaea* grains seem allied to those of *Passiflora*, in which each pair of furrows is linked just short of the poles. In these an area of the exine is isolated, whereas in *Teucridium* the whole mechanism seems to act as a much modified single furrow enclosing an opercular thickening equivalent to the middle of the pore, somewhat as in *Nymphaea*.

(4) contd

Pores circular.
Rims thickened; 18μ.
Cross-furrows present .... ARALIACEAE **Schefflera**
Cross-furrows absent ...... SAPINDACEAE **Alectryon**
Rims unthickened.
Size 20μ .... CAMPANULACEAE **Lobelia**
Size 25μ .... CALLITRICHACEAE **Callitriche**
Size 38μ; furrows 5, 6 .... LABIATAE **Mentha**

Pores weakly defined, membrane often bulging.

Furrows wide, short; 20 to 40μ.
Grain flattened; 28μ .... STYLIDIACEAE **Donatia***
Grain rounded .... CAMPANULACEAE
Size 36μ; exine fairly thick .... **Colensoa**
Size 20 to 30μ; exine thinner .... **Pratia** **Isotoma**
Furrows narrow, long; exine thin...CRUCIFERAE
Pitting uniform.
Size 20μ .... **Pachycladon**
Size 26μ .... **Sisymbrium**
Pitting graded.
Size 18μ .... **Cheesemania**
Size 22μ .... **Nasturtium palustre**

(5) **EXINE PAPILLATE-GRANULAR.**
Furrows 3, sometimes 6 or 4, distinct, functional.

Pores present; exine moderately thick to very thick.

Membrane unpatterned; furrows 4, or 3; 24μ LORANTHACEAE **Tupeia**
Membrane patterned; granules of 2 sizes; 20μ LOGANIACEAE **Mitrasacme**
Pores absent; membrane usually patterned, bulging on expansion; grains spheroidal.
Size 60μ; pores obsolescent?; granules sub-echinate .... CONVOLVULACEAE **Convolvulus**
Size less than 50μ; no trace of pores; membrane not smooth; furrows typically wide RANUNCULACEAE
Margins smooth; 18 to 25μ .... **Caltha**
Margins rough or jagged.
Furrows wide; size 20 to 40μ .... **Ranunculus** **Myosurus**
Furrows narrow, often weak; 18 to 28μ....**Clematis**

Furrows 4, 3, or up to 9, coinciding with pores or both reduced and non-functional; grains strongly flattened. (See p. for more logical position.)

Size 45 to 65μ; furrows and pores 5 to 9, vestigial FAGACEAE **Nothofagus menziesii***
Size 27 to 43μ; furrows reduced, 4 or 3; pores vigorous .... STYLIDIACEAE*

(6) **EXINE FINELY GRANULAR OR MERELY FLECKED,** occasionally with additional warty granules, rarely striate; furrows typically 3; exine mainly thin and smooth.

Sculpture continuous, or very nearly so; furrows wide.

Pattern embracing whole surface.

Furrow distinct, whole membrane bulging on expansion.

Surface granular .... AIOZACEAE (**Ficoidaceae**)

Granules uniform; furrows 6, rarely 3, meridional; 26 to 36μ .... **Tetragonia**

Granules of 2 sizes; furrows 3; 26μ **Mesembryanthemum**

Furrow weak; pattern netted.

Pores protruding; grains angular between pores, flattened; 20 to 26μ .... ROSACEAE **Acaena***

Pores lost; grains spheroidal; 18μ ...... OLEACEAE **Olea***

Pattern lacking only on furrow "ring," continuous over large membrane; exine thick, flecked or pitted; 42μ .... VERBENACEAE **Teucridium***

Sculpture not continuous over furrow membrane.

Sculpture patchy, flecked; 20μ.

Furrows narrow; 3, beaded on rims ...... LABIATAE **Scutellaria**

Furrows wide, 4 or more, rarely 3 or 5; flecked around pores .... SCROPHULARIACEAE **Glossostigma**

Sculpture even.

Furrows wide, meridional (unless hexacolpate).

Furrows 4, or 5, very wide, rounded at end; pores large; exine very thick, granular; 30μ .... SAXIFRAGACEAE **Ixerba**

Furrows 4, or 3, tapering.

Pores fairly large.

Furrows short; 18-24μ .. SCROPHULARIACEAE **Mimulus*** **Mazus***

Furrows long.

Exine thick (2-3μ), granular or pitted; 22 to 32μ .... PITTOSPORACEAE **Pittosporum***

Exine about 2μ; furrow rim thickened; 24 to 34μ .... CORNACEAE **Corokia**

Exine thin.

Size 20 to 40μ; pores like papillae.

Pattern flecked.

Size 18μ .... GUTTIFERAE **Hypericum**

Size c.22μ .... PITTOSPORACEAE **Pittosporum***

Pattern coarser .... ROSACEAE

Size 18μ; rather striate .... **Rubus**

Size c.20μ .... **Potentilla** **Acaena*, Geum**

Size 35 to 55μ; pores sharply defined; more granular ..... CAPRIFOLIACEAE **Alseuosmia**

(6) contd.

Pores small; exine thin.

Grains less than 30μ; furrows tending to split.

Exine flecked; furrows sometimes 6 .... VIOLACEAE

Size 12 to 20μ .... **Melicytus**

Size 25 to 32μ .... **Viola**

Exine granular .... RHAMNACEAE

Size 25 to 32μ .... **Pomaderris**

Size 20μ; exine thinner .... **Discaria**

Exine pebbled; 27μ .... GENTIANACEAE **Sebaea**

Grains 36μ; furrows not rupturing .... UMBELLIFERAE **Eryngium**

Furrows narrow, typically 3, functioning little or at most by "hinge" action; pores equatorial, small.

Grains flattened; furrow rims parallel.

Furrows meeting to enclose polar "islands."

Size 17μ; furrows 3.............. MYRTACEAE **Eugenia***

Size 28μ; furrows 4 .... GENTIANACEAE **Liparophyllum***

Furrows not meeting; angles of grain truncate.

Size 18μ; exine very thin .... MYRTACEAE **Myrtus**

Size 24μ; exine thick .... LORANTHACEAE **Loranthus**

Grains not flattened; furrows long, usually slightly tapering; pores commonly prominent.

Grains spindle-shaped.

Size 16μ .... PRIMULACEAE **Samolus**

Size 20μ .... ELATINACEAE **Elatine**

Size 24μ, pore comparatively large .... TETRACHONDRACEAE **Tetrachondra***

Size 26μ, pores minute .. SCROPHULARIACEAE **Hebe & Veronica**

Grains more spheroidal, or ellipsoidal when contracted; pores often wider than furrows; exine flecked.

Furrows 4, or 5; 20μ .... EPACRIDACEAE **Leucopogon fasciculatus**

Furrows 3.

Size 16μ; exine very thin .... RUTACEAE **Phebalium**

Size 20μ; exine thin .... GESNERACEAE **Rhabdothamnus**

Size 26μ; furrows narrower; exine thick .... POLYGONACEAE **Muehlenbeckia***

Size 30μ; furrows riftlike; exine fairly thick .... SAPOTACEAE **Sideroxylon**

Grains dumb-bell shaped unexpanded; pores with cross-furrows; exine very thin, mesh faint; about 20μ
UMBELLIFERAE (most genera)
Apium; Anisotome; Aciphylla; Actinotus; Daucus; Lilaeopsis; Oreomyrrhis; Schizeilema, etc.

(7) **EXINE PATTERNLESS** (or at most obscurely flecked), very thin; surface perfectly smooth; furrows typically meridional, with or without small equatorial pores.

Grains typically tricolpate; 6 or 4 furrows occasional.

Grains strongly flattened, sharply triangular; furrows narrow, linked by arci; 12 to 20μ .MYRTACEAE
Leptospermum
Metrosideros
Eugenia*

Grains ellipsoidal; furrows narrow.

Size 6 to 8μ; furrows slitlike; pores obscure
BORAGINACEAE
Myosotidium

Size 20 to 30μ; furrows long and narrow, often vestigal; pores aspidate with cross-furrows.

Cross-furrows making equatorial circuit; size 22 by 16μ .... SANTALACEAE
Exocarpus

Cross-furrows not meeting (or rarely).
Furrows long; 20 to 30μ .... ARALIACEAE
Stilbocarpa

Furrows shorter, weaker; size 20 to 25μ
UMBELLIFERAE
Actinotus*
Coxella
Lilaeopsis*
Daucus*

Grains spheroidal or oblately flattened, sometimes rounded-triangular in outline when expanded.

Size 20μ or less; usually rather flattened.

Furrows wide and tapering; flattened.

Furrows defined; pores aspidate .... VIOLACEAE
Size 12 to 18μ .... **Melicytus***
Size 19μ; exine thicker .... **Hymenanthera**
Furrows vaguely outlined; pores not aspidate; 19μ .... ICACINACEAE
Pennantia

Furrows narrow, much longer; grains less flattened.
Grains somewhat flattened.
Size 10μ; furrows 3 or 6 .... CUNONIACEAE
Ackama
Size 11 to 15μ .... CRASSULACEAE
Tillaea

Grains not flattened.
Size 11 to 15μ; unflecked
ELAEOCARPACEAE
11μ .... **Elaeocarpus**
15μ .... **Aristotelia**
Size 12μ; flecked near pores
SCROPHULARIACEAE
Jovellana*

(7) contd. Size more than 20μ; furrows weakly defined, tapering.
Furrows typically 3.
Furrows wide, membranes bulging; 24μ PAPILIONACEAE
Sophora
Furrows narrow; 28μ .... TETRACHONDRACEAE
Tetrachondra
Furrows 4, or 5, more rarely 3.
Size 24μ; pores not aspidate ..... MYRSINACEAE
Suttonia
Size 21μ; pores aspidate .... SOLANACEAE
Solanum

Grains not tricolpate, having 4, 5, or 6 long, narrow, meridional (possibly oblique) furrows; pores mainly very small, vigorous.

Grains ellipsoidal, constricted at waist; 12 to 20μ BORAGINACEAE
Myosotis*
Grains spheroidal to discoid; exine thin.
Grains 4-angled; 21μ .... SCROPHULARIACEAE
Gratiola
Grains not angled.
Pores present.
Size 15μ; furrows 5, or 4, tapering sharply SAXIFRAGACEAE
Quintinia
Size 30μ; furrows 5, or 6, blunt LENTIBULARIACEAE
Utricularia
Size 34μ; furrows 4, riftlike .... MELIACEAE
Dysoxylum*
Pores absent; furrows 4, 5, or 3; 10 to 20μ RUBIACEAE
Size 13μ; exine sometimes flecked .... **Galium**
Size 20μ; furrows longer, often curved .. **Asperula**

(b) **FURROWS ALMOST ELIMINATED, coinciding with the pores, or both vestigial. Transitional types,** mainly repeated in sections to which they most nearly approach.

(1) **Furrows not merely coinciding with pores,** but extending beyond as rifts or lines of weakness.

Pores clear, wider than the 4 or 6 furrows.
Grains spheroidal.
Size 34μ .... MELIACEAE
Dysoxylum*
Size 42μ .... EPACRIDACEAE
Leucopogon frazeri
Grains flattened; furrows vague; pore rim unthickened.
Exine papillate .... STYLIDIACEAE
Exine thin.
Pattern warty; 30μ .... **Oreostylidium**
Pattern fine; 42μ .... **Phyllachne**
Exine thick; 28μ .... **Forstera**
Exine faintly flecked, very thin; 21μ SCROPHULARIACEAE
Limosella
Mimulus*
Mazus*

Pores obscure or lacking; furrows riftlike; exine very thin.
Grains flattened; vestigial furrows and pores indicated by 5-7-9 angles on the equator; papillate; 45 to 65μ .... FAGACEAE
Nothofagus menziesii*
Grains spheroidal.
Furrow-lines 3; warty-flecked; 30μ ...... RUBIACEAE
Nertera
Furrows 4; pitted; 34μ .... POLYGONACEAE
Rumex*
Furrows 6-8; spiny; 55μ .... CUCUBITACEAE
Sicyos*

(2) **Furrows coinciding with elongate pores** (i.e., **eliminated, sensu stricto,** but original orientation suggested by the pores).

Slits meridional, mainly aspidate and pouting; grains flattened.
Pores 5-8; papillate; 22-40μ .... FAGACEAE
Nothofagus (fusa type)
Pores 3 or 4 (rarely 6, then not meridional).
Membrane large, exposed; 35μ ... HALORAGIDACEAE
Gunnera*
Membrane minute, sunken.
Pores pouting, forming angles.
Exine reticulate-granular; 28μ
HALORAGIDACEAE
Myriophyllum
Exine flecked.
Size 25μ; furrows 3 .... CORIARIACEAE
Coriaria*
Size 32-48μ; furrows 4, or more
HALORAGIDACEAE
Haloragis

Slits not meridional, equidistant.
Furrows 6; pitted.
Size 22μ .... CARYOPHYLLACEAE
Spergularia?
Size 35μ .... HALORAGIDACEAE
Gunnera*
Furrows 12 or 15, rarely more.
Exine flecked; 48μ .... NYCTAGINACEAE
Heimerlia*
Exine reticulate to pitted .... PORTULACCACEAE
Size 46μ; mesh bold .... **Claytonia***
Size 36μ; mesh weaker .... **Montia***

(c) **FURROWS COMPLETELY ELIMINATED; PORES PRESENT,** typically circular—not reminiscent of furrows. **PORED GRAINS** (excluding monocolpate forms).

(1) **GRAINS SPINY.**

Surface reticulate, pitted, or granular; spines scattered.

Pores very numerous; exine reticulate or pitted, thick.
Size 70μ; reticulate; spines long. .CONVOLVULACEAE
Ipomoea
Size 100 to 130μ; pitted, very thick; spines exceedingly long .... MALVACEAE
Hibiscus
Pores few (4 to 6), rimmed; granular .... MALVACEAE

Size 30μ; pores rather large; spines short, crowded .... **Plagianthus**
Size 40μ; pores smaller; spines longer (5μ), less crowded .... **Hoheria**

Surface lophate with spines on ridges; pores 3 or 4, large .... CICHORIEAE*

(2) **GRAINS NOT SPINY.**

Pores equatorial, circular; usually with thickened rims.
Grains dicolpate; pores opposed.

Grains elongate, over 22μ; exine firm.

Size 65μ; pores very conspicuous; vestibules flasklike .... ONAGRACEAE **Fuchsia**
Size 22 by 16μ; pores inconspicuous; vestibules small .... CORYNOCARPACEAE **Corynocarpus**
Grains spherical, mainly less than 22μ; pores inconspicuous; exine weak, patternless URTICACEAE and MORACEAE*
Size 10μ or less .... **Australina** **Elatostema**
Size 14μ .... **Boehmeria** **Parietaria**
Size 16 to 23μ .... **Urtica** spp. **Paratrophis opaca**

Grains typically tricolpate, occasionally tetracolpate (very rarely dicolpate).

Pores with ornamented collars; patternless; 28μ APOCYNACEAE **Parsonsia***
Pores without ornamented collars.

Grains flattened; angular; exine mainly thick, patterned.
Pores very conspicuous; size 40 to 100μ ONAGRACEAE **Epilobium***
Pores inconspicuous.
Size 45 to 60μ; grains 3-armed LORANTHACEAE **Elytranthe**
Size 30 to 36μ .... PROTEACEAE
Exine papillate .... **Persoonia**
Exine pitted .... **Knightia**
Size 25μ.
Exine finely netted .... SANTALACEAE **Mida**
Exine pitted .... LORANTHACEAE **Korthalsella**
Exine flecked .... CORIARIACEAE* **Coriaria**

Grains neither flattened nor angled; exine very thin, patternless.
Grains spherical; pores 2-4 URTICACEAE and MORACEAE
Size 10 to 20μ .... **Urtica***
Size 14 to 23μ .... **Paratrophis**
Grains ellipsoidal; pores 3; 20μ .. LOGANIACEAE **Geniostoma**

(2) contd. **Pores scattered,** often equidistant; definite symmetry indicated when pores elliptic; grains spheroidal or occasionally elongate.

Pores not exceeding 15.

Pores elliptic, typically 12.

Exine very thick; mesh strongest in intercolpar areas .... PORTULACCACEAE

Size 46μ; mesh bold .... **Claytonia***

Size 36μ; mesh weaker .... **Montia***

Exine less thick, flecked; furrows 12 to 15 (number rarely doubled); 48μ NYCTAGINACEAE **Heimerlia***

Pores circular, clearly defined.

Exine thick, pores predominantly 12.

Pores large, membrane more or less patterned.

Pores very large, rims weak; 55 to 75μ LINACEAE **Linum**

Pores smaller, rims thickened; 36 to 46μ CAMPANULACEAE **Wahlenbergia**

Pores small; membrane unpatterned; 20 to 40μ .... CARYOPHYLLACEAE

Size about 20μ .... **Colobanthus**

Size 30 to 40μ .... **Stellaria**

Exine thin; pores 4 to 12.

Pores rather large.

Exine lophate; ridge adorned, lacunae 12; 16μ .... AMARANTHACEAE **Alternanthera***

Exine not lophate.

Pores 16, with collars; 38μ BALANOPHORACEAE **Dactylanthus**

Pores 6, collarless; 46μ ..... EPACRIDACEAE **Leucopogon frazeri***

Pores small; 4 to 6.

Collar vertically thickened; 28μ APOCYNACEAE **Parsonsia***

Collar obscure; 23μ ...... PLANTAGINACEAE **Plantago**

Pores exceeding 15 (not always distinct from mesh in reticulate grains).

Pores large; exine thick, pebbled; membrane patterned; 48μ .... CONVOLVULACEAE **Calystegia**

Pores small; membrane unpatterned.

Exine reticulate, very thick.

Size 50 to 70μ; mesh very large POLYGONACEAE **Polygonum**

Size 30 to 48μ; mesh small .. THYMELAEACEAE

Size 40μ; pores clear ....**Pimelea**

Size 30μ; pores obscure; pitted .... **Drapetes**

Exine pitted or reduced; 16 to 26μ CHENOPODIACEAE

Pores 40 to 50.
Exine thick, pitted .... **Atriplex**
Exine thin.
Exine pitted; 24μ .... **Salicornia**
Exine flecked; 20μ .... **Suaeda**

Pores 30 or fewer; pattern reduced.
Size 23μ .... **Rhagodia**
Size mainly less than 20μ; surface more wrinkled .... **Chenopodium**

II. GRAINS COMPOUND, arranged in **tetrads** (mainly tetrahedral).

(A) **GRAINS COLPATE: components each with one or three** (rarely more) **furrows and/or pores.**

1. **Furrows present,** 3 per component; pores against contact faces.

Furrows untapering; pores inconspicuous; exine patternless; tetrads 38μ in diameter .... SAXIFRAGACEAE
Carpodetus

Furrows tapering; tetrads mainly less than 35μ.

Tetrads compact; pores sharp.
Exine flecked; rarely pitted; tetrad c. 32μ ..... ERICACEAE
Exine very thin; furrows rather short; pores 5μ **Gaultheria**
Exine thicker; furrows longer; pores smaller . . **Pernettya**
Exine almost patternless; tetrads 25-38μ . . EPACRIDACEAE
Exine thick; furrows long and narrow; up to 38μ **Epacris**
Exine thin.
Furrows very short; 25-35μ .... **Dracophyllum**
Furrows short; up to 38μ .... **Pentachondra**
Furrows long; quite patternless; 30μ ...... **Cyathodes***
Tetrads loose, variously arranged, 30μ; furrows weak; pores obscure .... **Archeria**

2. **Furrows reduced to pores.**

(a) Components with one furrow-pore area.
Tetrad square, 40μ; faintly reticulate .... MONIMIACEAE
Hedycarya*†
Tetrad tetrahedral; "pore" large, circular.
Exine strongly reticulate; "pore" sharp; tetrads 50μ
MAGNOLIACEAE
Drimys
Exine almost or quite patternless; "pore" vague but vigorous, reinforced by hyaline bodies ... JUNCACEAE†

Tetrads over 50μ .... **Juncus***
Tetrads less than 50μ.
Organisation obscure.
Size 30μ .... **Rostkovia***
Size 36μ .... **J. maritimus**
Organisation clear.
Size 30μ .... **Rostkovia***
Size 36μ .... **Luzula**

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†By extreme reduction grains of **Hedycarya** and **Juncus** may merge into the Acolpate group [II. (B.)], but careful examination should reveal their derivation.

(b) Components with 3 or more pores.

Pores 3, equatorial; tetrads variously arranged, **components** mainly over 40μ .... ONAGRACEAE
Epilobium*

Pores 12-18, hidden in channels on dorsal side of grains; ventral side widest, spiny; tetrads tetrahedral, **components** 30-44μ .... DROSERACEAE
Drosera

(B) **GRAINS ACOLPATE;** i.e., **without either furrows or pores;** exine thin. Tetrad formation rarely obligate ... ORCHIDACEAE

Exine patternless; tetrads tetrahedral or square; **components** 16μ .... **Earina** type

Exine reticulate.

Tetrads compact; **components** 20μ; mesh strong .... **Pterostylis** type

Tetrads loose; **components** 26μ; mesh weaker ..... **Chiloglottis** type

REFERENCES.

ARMBRUSTER, L., & OENIKE, G. 1929. Die Pollenformen als Mittel zur Honigerkunstbestimmung. Wachholtz; Neumunster in Holstein.

AUER, V. 1933. Verschiebungen der Wald-und Steppengebiete Feuerlands in Postglazialer Zeit. Acta Geogr. 5, 2, pp. 1-313.

CRANWELL, LUCY M. 1938. Fossil Pollens. N.Z. Journ. Sci. & Tech., 19, pp. 628-645.

1939. Southern-Beech Pollens. Rec. Akld. Inst. & Mus. 2, pp. 175-196.

1940. Pollen Grains of the New Zealand Conifers. N.Z. Journ. Sci. & Tech., 22, No. IB, pp. 1B-17B.

CRANWELL, LUCY M., & VON POST, L. 1936. Post-Pleistocene Pollen Diagrams from the Southern Hemisphere: I, New Zealand. Geografiska Annaler, H. 3-4, pp. 308-347.

ENGLER, A. 1926. Angiospermae. Die Nat. Pflanzenfamilien, Bd. 14a, Zweite Auflage. Leipzig, pp. 1-167.

ERDTMAN, GUNNAR. 1936. New Methods in Pollen Analysis. Svensk. Bot. Tidskr. Bd. 30, H.2.

HEGELMAIER, F. 1868. Die Lemnaceen: Eine Monographische Untersuchung. Engelmann, Leipzig.

HUTCHINSON, J. 1926. Families of Flowering Plants. I. Dicotyledons. MacMillan & Co., London.

1934. II. Monocotyledons. Ibid. pp. 1-243.

MERCER, F. V. 1940. Atmospheric Pollen in the City of Adelaide and Environs. Trans. Roy. Soc. S. Austr. 63.

SKOTTSBERG, C. 1936. Arboreous Nyctaginaceae of Hawaii. Svensk Bot. Tidskr. Bd. 30, H.3.

1939. A hybrid violet from the Hawaiian Islands. Botan. Notiser. Lund.

1940. Notas sobre el genero Arjona. Revista Universitaria. 25, 3, pp. 103-108.

SMITH & WODEHOUSE, R. P. 1938. American species of Myristicaceae. Brittonia, Vol. 2, 5, pp. 397-402.

WODEHOUSE, R. P. 1935. Pollen Grains. McGraw Hill Book Co., N.Y. (pp. 1-574).